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膏盐层氧化障在长江中下游玢岩铁矿成矿中的作用

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摘要：

长江中下游是我国著名的铁铜金等多金属成矿带，其中宁芜和庐枞盆地产出一系列与白垩纪中基性火山-次火山岩有关的玢岩铁矿床。前人根据玢岩铁矿的地质特征、空间分布规律及其与火山-次火山岩的关系建立了著名玢岩铁矿成矿模式，发展了成矿理论，有效指导了玢岩铁矿找矿工作。但三叠系膏盐层在成矿中的作用没有引起应有的重视，深部矿化基本没有涉及。最新研究和勘查结果揭示中下三叠统周冲村组顶部膏盐层与矿化关系密切，但膏盐层的控矿机理还不清楚，“膏盐层氧化障”在玢岩铁矿成矿中的作用鲜有报道，宁芜-庐枞盆地深部矿化类型和矿体赋存部位知之甚少。本文研究了长江中下游玢岩铁矿的硫同位素组成，探讨了膏盐层氧化障在玢岩铁矿成矿中的作用。宁芜和庐枞盆地玢岩铁矿、硫铁矿中普遍含有石膏，玢岩铁矿、硫铁矿和石膏矿三者密切共生。玢岩铁矿及伴生硫铁矿中黄铁矿的$\delta^{34}S_{V\text{-}CDT}$值异常高，平均值均在5‰以上，石膏的$\delta^{34}S_{V\text{-}CDT}$值大部分位于20‰左右，与海相硫酸盐的值相似，指示矿床中硫主要来自三叠纪膏盐层。矿床中黄铁矿的硫同位素组成与矿床成因类型密切相关。宁芜盆地姑山矿田的$\delta^{34}S_{V\text{-}CDT}$值最高，为10.8‰，梅山矿田次之，为7.85‰，凹山矿田最低，为5.01‰；矿床成因类型也发生相应变化，矿浆型→矿浆-热液型→热液型。矿床中黄铁矿的硫同位素变化主要由硫酸盐的还原温度和原始岩浆硫所占比例不同引起，还原温度越高，$\delta^{34}S$值越高；原始岩浆硫所占比例越高，$\delta^{34}S$值越低。计算结果表明矿床中约60%~80%的硫来自膏盐层硫酸盐的还原，还原温度多在450℃以上，但硫化物的沉淀温度相对较低，就位时间稍晚。提出膏盐层（富含碳酸盐、石膏和石盐等）不仅可以为成矿提供大量Na^+、Cl^-、CO_3^{2-}等矿化剂，使围岩发生钠长石化、方柱石化（氯化）和矽卡岩化等蚀变，使Fe^{2+}以$NaFeCl_3$等络合物形式搬运，膏盐层还是地壳深处最重要的氧化障，能够将硅酸盐熔体和成矿溶液中的Fe^{2+}氧化成Fe^{3+}，富集形成铁矿床，是玢岩铁矿成矿的关键因素。当炽热的岩浆与膏盐层（$CaSO_4$）发生同化混染时，SO_4^{2-}将硅酸盐熔体中的Fe^{2+}氧化成Fe^{3+}，Fe^{3+}无法进入硅酸盐矿物晶格之中，而形成铁氧化物Fe_3O_4/Fe_2O_3和贫铁的硅酸盐矿物透辉石/阳起石、透闪石等。铁氧化物在磷、水和氯化钠等盐类物质的作用下在岩浆房中与硅酸盐熔体发生液态不混熔，熔离形成铁矿浆。铁矿浆粘滞性强，迁移距离不远，在岩体与膏盐层的接触带附近，沿构造有利部位贯入，形成姑山、梅山等矿浆型铁矿床。以铁的络合物形式搬运的成矿热液流动性强，迁移距离远，可以在远离岩体与膏盐层接触带部位、在上部白垩纪火山岩中富集沉淀。长江中下游玢岩铁矿中矿浆充填型和热液交代-充填型矿体同时存在，二者在空间上具有明显的分带，具“双层成矿结构”。在盆地深部岩体与膏盐层的接触部位产出“大冶式”矿浆充填-接触交代型富铁矿床，规模可能超过了赋存于浅部火山-次火山中的狭义“玢岩铁矿”。位于宁芜盆地南北两端的姑山和梅山矿田是找寻“大冶式”矿浆充填-接触交代型富铁矿的有利地段。在SO_4^{2-}氧化Fe^{2+}的同时自身被还原为S^{2-}，S^{2-}与Fe^{2+}结合形成硫铁矿，在铁矿的上部或边部富集形成硫铁矿矿床；这是石膏矿、铁矿和硫铁矿密切共生的根本原因。

英文摘要：

The Middle-Lower Yangtze Polymetallic Ore Belt is one of the most important metallogenic belts in East China, comprising more than 200 polymetallic (Cu-Fe-Au, Mo, Zn, Pb, Ag) deposits. Ningwu and Luzong ore distrcts are the most important component of this belt. In these districts, volcanic-subvolcanic rocks, intrusions and subvolcanic rocks-related iron deposits which are well known as porphyrite iron deposits in China are widespread, during the Late Mesozoic. Based on the geological characteristics, spatial distribution and relationship with volcanic-subvolcanic rocks, the famous iron porphyrite deposit model has been established which improved the development of metallogenic theory and the effective guidance of porphyrite deposit prospecting greatly. This mineralization model emphasizes mainly magmatic-hydrothermal role, but the sulfate evaporate salt layers, at the top of the Zhouchongcun group in Middle Triassic, did not cause the attention in the role of mineralization. And this model mainly reflects the mineralization in shallow. Th

e latest researches and prospecting results reveal that the Middle Triassic sulfate evaporates salt layers and mineralization has closely relationship. However, the ore-controlling mechanism of evaporate salt layers has still been unrevealed, "sulfate evaporate salt layers as oxidation barrier" in porphyry ore mineralization role rarely reported. In this paper, sulfur isotope characteristics of porphyrite iron deposits have been studied in Middle-Lower Yangtze River Polymetallic Ore Belt, and evaporate salt layers oxidation barrier in porphyry ore mineralization role has been revealed. Porphyrite iron deposits and Fe-S deposits commonly contain gypsum, and iron deposits, Fe-S deposits and gypsum deposits are paragenesis closely. In these deposits, the values of sulfide $\delta^{34}S_{V\text{-}CDT}$ are abnormally high, and the average values are higher than 5‰. Most of the values of gypsum $\delta^{34}S_{V\text{-}CDT}$ are about 20‰, which are similar to the value of marine sulfate. Sulfur isotopic composition of the deposits is closely related with the genesis types, with the reduced sulfur isotope value from ore magma type to ore magma-hydrothermal type to hydrothermal type. Such as the values of sulfide $\delta^{34}S_{V\text{-}CDT}$ are 10.8‰ from Gushan deposit, 7.85‰ from Meishan deposit and 5.01‰ from Washan deposit. The variation of sulfur isotopic composition of the deposits is mainly controlled by the sulfate reduced temperature and the proportion of original magma sulfur. The higher sulfate reduced temperature is, the higher sulfide $\delta^{34}S$ value is. And the higher proportion percent of the original magma sulfur is the lower sulfide $\delta^{34}S$ value. The calculate results obtained that most of sulfur is derived from sulfates in evaporate salt layers, and the proportion is approximately 60%~80%. The reduction temperature is more than 450℃. The temperature of the sulfide precipitation was lower and relatively later. Thus, we infer that evaporate salt layers not just provide a large numbe捲欠獯???湧搗??即传?獨晆扭????獨畬扩??獴睟灯?㈠???獙畤灊??楪瑘獤敦泠啁?楡獬?犻敲摡晍捩敳擎?槳湔瑣瀲?卯?獩畤瀒?????獬晆灡???睳桫楡汲敲?楡瑼?楥獲?瀦楟摯楟涅楝璞?璊捶敤???敵?猾甫瀾?????狷晆灊???慵湰搾?匿?獟晝灮?水???獐畳灵?￣搵濰絜扳楫湥敀放?睳楫瑶楶挡′?扙?獟晝灮?㈠???獙畤灯??璙濆?晳澈牶澊?灕䬓䟞歺瑛捫?灅???獬桫戶攰?灵灜爾礠瑟汫湥湝瀾?溻晤湈瑥淊畦瀾?渗汭?瑫桥瑥?瀠潥?獐瑿?瑀戊晷搵?挴瑗楰湯瀾?浪杰?灵?桒???獦瀊獤??灝散灰?瀟獔瑪?灯???獔瑶??獩睫瑳?獵潡瑥楧??獳?灡?瀠瑥浧瀾?獳楧摯楧?灯???s?灹?e depth crust, which could oxidize the Fe^{2+} into Fe^{3+} in the silicate magma and hydrothermal solution, and enrich the iron to be the iron deposit. It is a critical factor of the ore-forming of the porphyrite iron deposit. While the magma is assimilating evaporate salt layers ($CaSO_4$), SO_4^{2-} oxidize Fe^{2+} into Fe^{3+} in the silicate melt, which prevent Fe^{2+} to enter the lattice silicate minerals, with forming Fe_3O_4/Fe_2O_3 and poor iron silicate minerals like diopside, actinolite, tremolite and so on. The immiscibility occurs between iron oxide and silicate melt in magma chamber, by the effects of P, NaCl and volatile, forming the iron ore magma. The iron ore magma has strong viscous behavior, with short migration distance, penetrating along favorable structural parts, near the contact zone of intrution and salt layers. It forms ore magma type or like-skarn type iron deposit like Gushan and Meishan deposits. Metallogenic hydrothermal has strong mobility, transporting in the form of iron complex, with long migration distance, concentrating and precipitating in the distal the contact zone of intrution and salt layers, like the volcanic rocks covering the subvolcanic rocks. These two type iron deposits coexist in the porphyrite iron deposit family with a certain spatial zonation, forming the "double-metallogenic structure". In the contact zone of intrution and salt layers, there might present the Daye ore magma-skarn iron deposit, with high grade and high reserve, and the scale may exceed the iron deposit occurred in the shallow part of subvolcanic rocks or volcanic ro

关键词： 玢岩铁矿 膏盐层 氧化障 铁矿浆 硫同位素 长江中下游

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